THE CLINICAL SIGNIFICANCE OF LEFT INTRAVENTRICULAR BLOCKS*

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INTRODUCTION

THIS communication will discuss the pathophysiology, causes, and clinical significance of left intraventricular blocks in acquired and congenital heart disease. Special emphasis will be given to the association of right bundle-branch block (RBBB) with left intraventicular blocks as forms of "partial" bilateral bundle-branch block (PBBBB) and thus potential precursors of bilateral bundle-branch block (BBBB), i.e., complete heart block (CHB).

ANATOMY OF THE CONDUCTION SYSTEM OF THE LEFT VENTRICLE

At the top of the interventricular septum the common bundle bifurcates into a right and left bundle branch. Shortly after the left bundle appears on the left side of the septum, it divides into two major groups of fibers. One group fans out as a division of fibers that spreads superiorly and anteriorly over the subendocardium of the anterolateral-superior wall; this group is called the superior (anterior) division of the left bundle. The second group also fans out but radiates inferiorly and posteriorly to the inferior-posterior wall of the left ventricle; this radiation may be called the inferior (posterior) division of the left bundle. These two divisions anastomose freely peripherally in the subendocardial layers of the ventricle via a network of Purkinje fibers. Figure 1 illustrates these divisions or radiations viewed through the left ventricle.

ELECTROPATHOPHYSIOLOGY OF LEFT INTRAVENTRICULAR BLOCKS

Normally, excitation spreads simultaneously along both divisions of the left bundle. If a lesion interrupts the fibers of the superior division,

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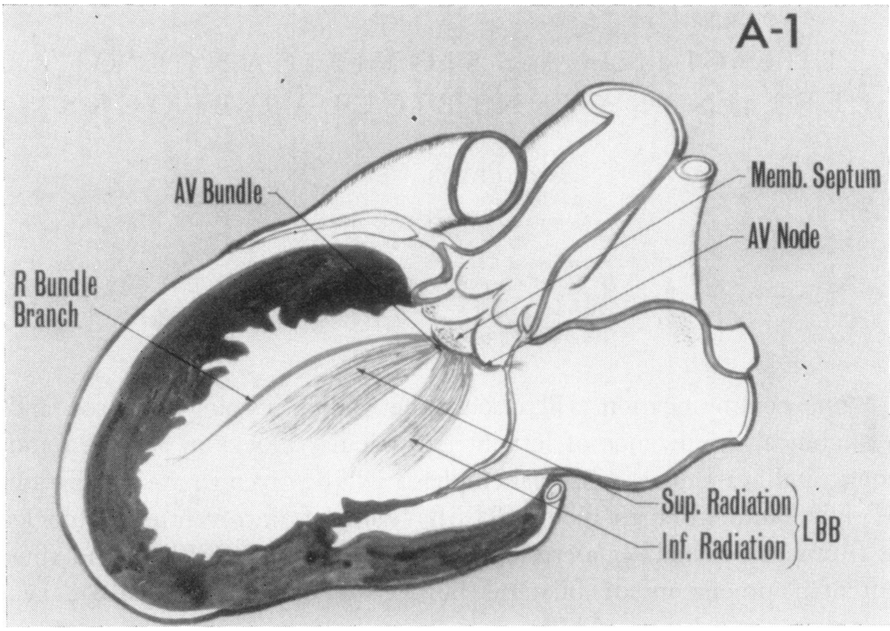

Fig. 1. Drawing of the superior radiation (anterior division) and inferior radiation (posterior division) of the left bundle viewed through the left ventricle.

the sequence of depolarization would be altered, i.e., excitation would spread initially down the inferior radiation, travel through Purkinje anastomoses, and then spread superiorly. The QRS loop would be counterclockwise (CCW), the terminal QRS vector would point to the left and superiorly, and left axis deviation (LAD), i.e., AQRS between 270° and 330°, would occur. If the lesion involving the superior radiation is fibrosis, the initial QRS vector is directed inferiorly and to the left (normal), causing a 0.02-second Q wave in lead aVL and 0.02-second r wave in lead III. The terminal vector would be directed toward the left and superiorly, with a tall terminal R in aVL and deep terminal S in leads II, III, and aVF; true LAD would result. Since the electrocardiographic changes occur largely in the frontal plane and as, anatomically, this division is both superior and anterior, we have elected to call this conduction defect left superior intraventricular block (SIVB). Other names for this conduction defect are: left anterior hemiblock, superior parietal block, anterior division block, superior radiation block, anterior fascicular block, and anterior arborization block. The electrocardiogram

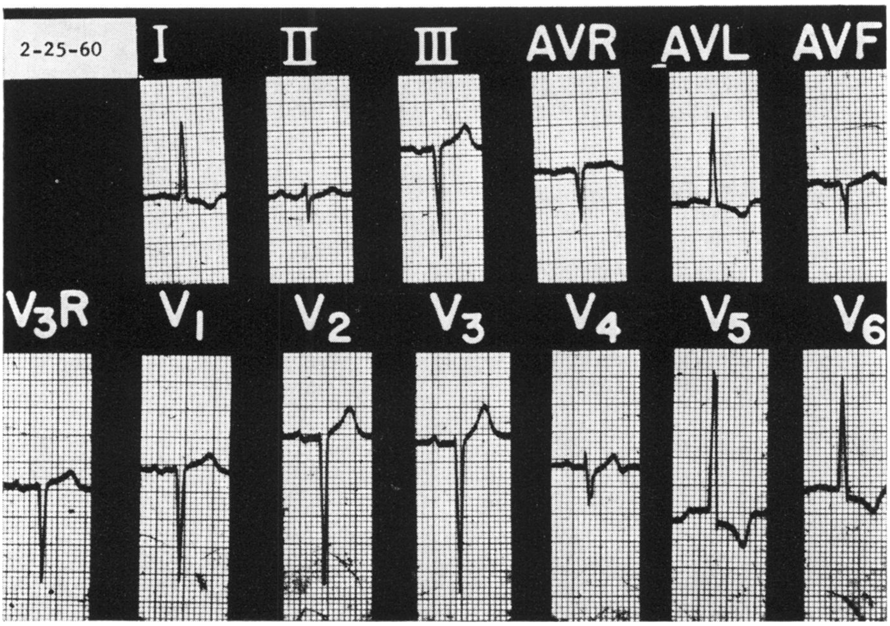

Fig. 2. ECG illustrating SIVB (left anterior hemiblock) in a patient with left ventricular enlargement.

(ECG) in Figure 2 illustrates SIVB. If the superior radiation is damaged by necrosis (infarction), the initial 0.04-second vector will point toward the right and inferiorly, away from the infarcted area, and a 0.04-second Q wave is recorded in AVL. The terminal vector would be directed leftward and superior with a CCW frontal plane loop, and LAD would result. This important electrocardiographic entity may be called left superior peri-infarction block (SPIB), but intraventricular block caused by infarction will be covered in another presentation at this meeting. Hence SPIB will not be discussed in this communication.

When the inferior (posterior) radiation is interrupted by fibrosis, early excitation travels through the superior (anterior) division causing the initial QRS vector to be directed horizontally leftward and somewhat inferiorly. Thus a small initial 0.02-second r wave in aVL and small initial 0.02-second Q wave in aVF will be seen. The terminal vector would point inferiorly at 90° to 110° with a clockwise (CW) loop and a large terminal S wave in aVL and large terminal R wave in aVF would be recorded. The ECG just described with an inferior or inferior-slightly-rightward terminal QRS vector with a CW loop is

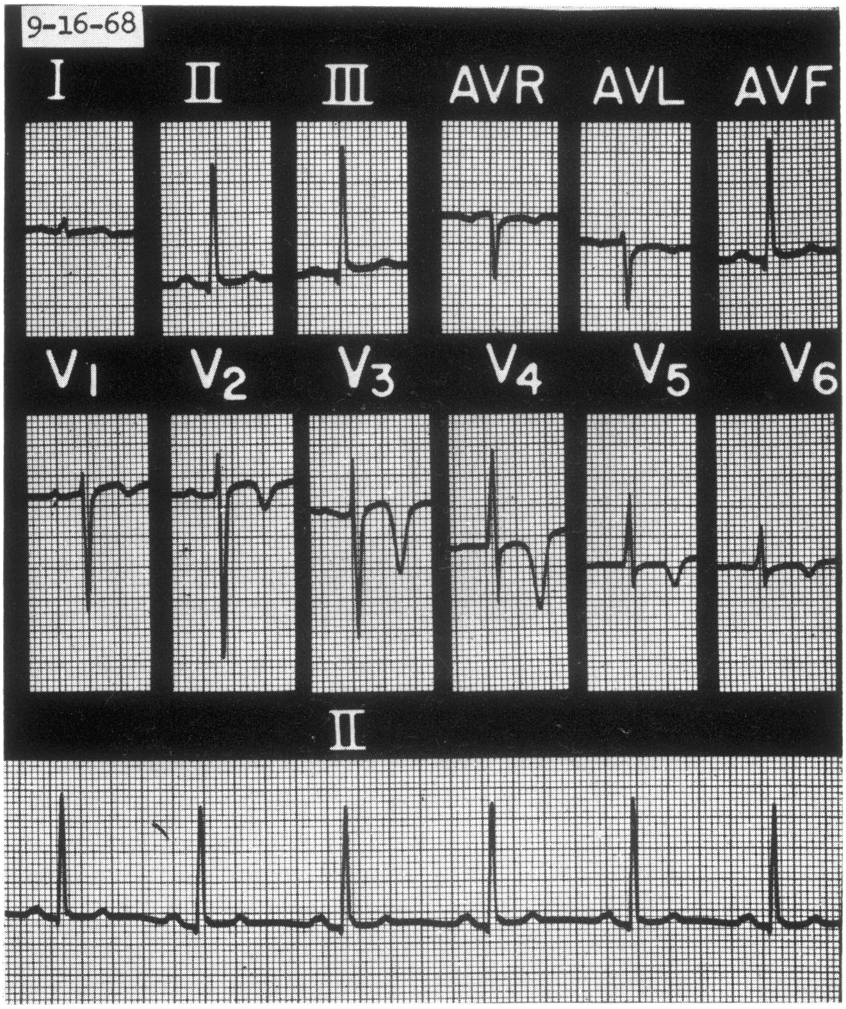

Fig. 3. ECG shows IIVB (left posterior hemiblock) in a patient with myocarditis and the BBBB syndrome—described in text.

normal in young people and tall slender older people but is unusual in adults of medium to heavy build. In the appropriate clinical setting, i.e., an adult with medium to heavy body build, with predisposing diseases such as coronary artery disease or hypertension—with right ventricular enlargement excluded, clinically the ECG described above may be abnormal, due to inferior radiation block, and this electrocardiographic entity may be called left inferior intraventricular block (IIVB) or left

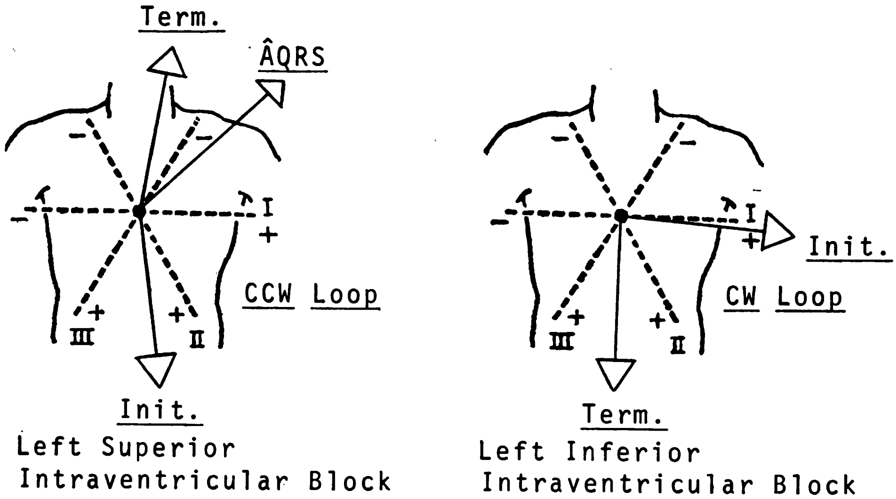

Fig. 4. Drawing of the vectors in SIVB and IIVB.

posterior hemiblock or posterior fascicular block. The ECG in Figure 3 illustrates IIVB and was taken on a 41-year-old patient who had myocarditis and the BBBB syndrome, to be described and illustrated later. Figure 4 illustrates the vectors in SIVB and IIVB.

Like Rosenbaum,[1,2] we[3] have been reading IIVB for many years but it took some time to find cases[4] of this relatively new entity that had been proved[2] at autopsy. Rosenbaum emphasizes that the anterior division: 1) receives blood supply from only one source, viz., the perforating arteries from the anterior descending artery; 2) is longer (25 mm. av.) and thinner (3 mm. av.) than the posterior division (20 mm. av. length, 6 mm. av. thickness); 3) belongs to the outflow tract of the left ventricle, which is a hemodynamically turbulent region, especially in the presence of arterial hypertension or disease of the aortic valve; that the posterior division is better protected than the anterior division and is less surrounded by potentially dangerous relations since: 1) its fibers are the first to leave the bundle of His; 2) it belongs to the inflow tract of the left ventricle, which is a less turbulent region; 3) the crossing from the septum to the posterior wall is short; 4) it has a double blood supply—from both anterior and posterior descending arteries; and 5) as stated above, it is shorter and thicker than the anterior division; therefore, this fascicle may be the least vulnerable segment of the whole ventricular conduction system and thus IIVB is seen much

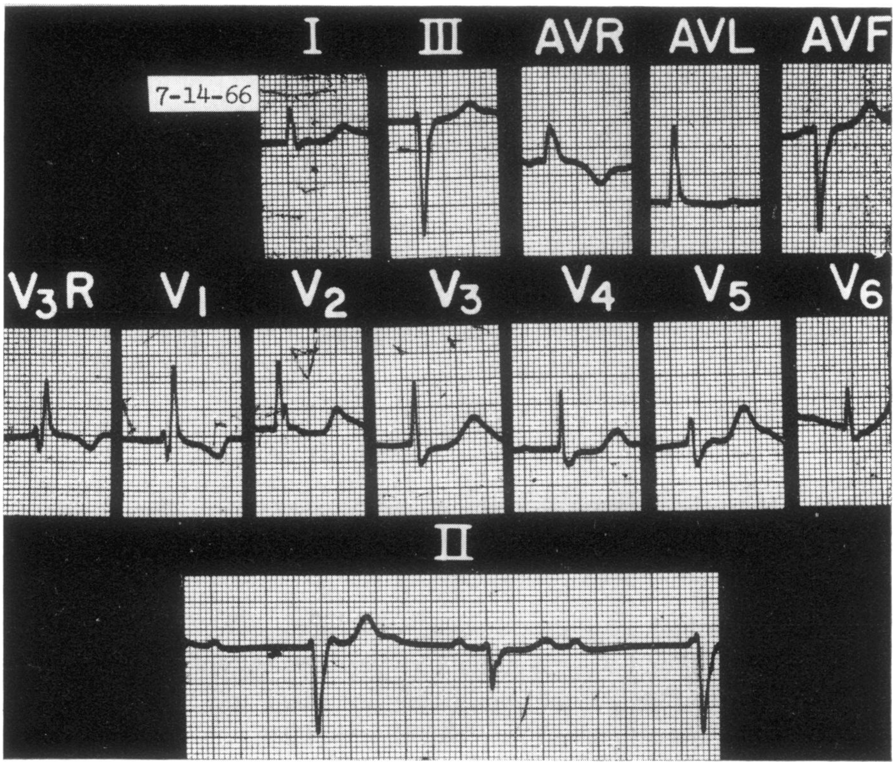

Fig. 5. ECG illustrating RBBB, LAD of unblocked QRS forces—SIVB—thus PBBBB. CHB in lead II with second beat captured means that BBBB has occurred.

less frequently than SIVB or RBBB, both clinically and in autopsy specimens. It is possible that IIVB may be more serious since it may require a more extensive disease process to cause it.

If there are initial Q waves lasting 0.04 seconds, followed by tall terminal R waves in leads II, III, and aVF, the term inferior or posterior peri-infarction block (IPIB) may be used.

Causes and Clinical Significance of Intraventricular Blocks

The most common cause of SIVB and IIVB is fibrosis due to coronary artery disease but intraventricular block is seen commonly in patients who have hypertension, diabetes, obesity, or disease of the aortic valve. During a period of five years we collected 302 new cases of LAD; more than 80% had one or more of the above diseases just mentioned. Most of our IIVB patients have also had one of these diseases.

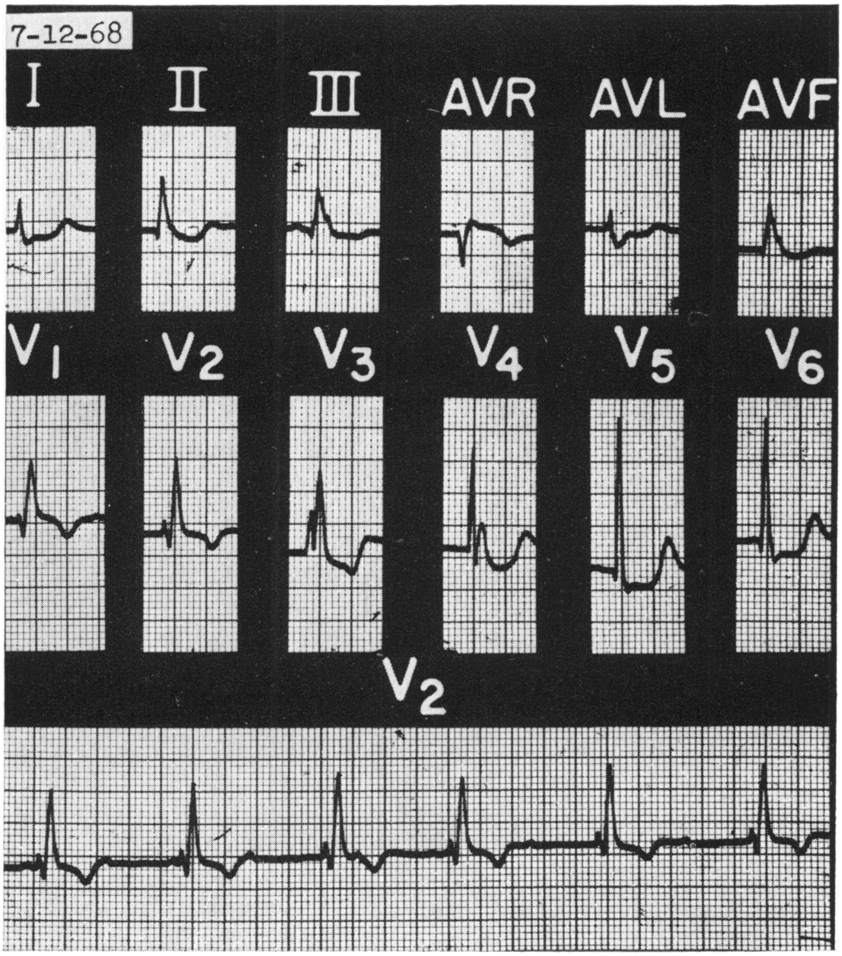

Fig. 6. ECG on 74-year-old male shows RBBB and IIVB. V_2 rhythm strip reveals CHB with the fourth beat captured—thus BBBB is present.

LAD has been reported in diseases that involve the myocardium primarily or secondarily, e.g., cardiomyopathy (obscure, familial, or alcoholic), myocarditis, amyloidosis, scleroderma, hemochromatosis, myotonia atrophica, progressive muscular dystrophy, and Friedreich's ataxia. Hyperkalemia and possibly hypokalemia are potential causes of reversible LAD. Surgical injury to the superior radiation with resultant SIVB may occur after surgical operation for obstruction of the left ventricular tract is especially common if the obstruction was caused by stenosis, both the muscular and the discrete fibrous types. SIVB occa-

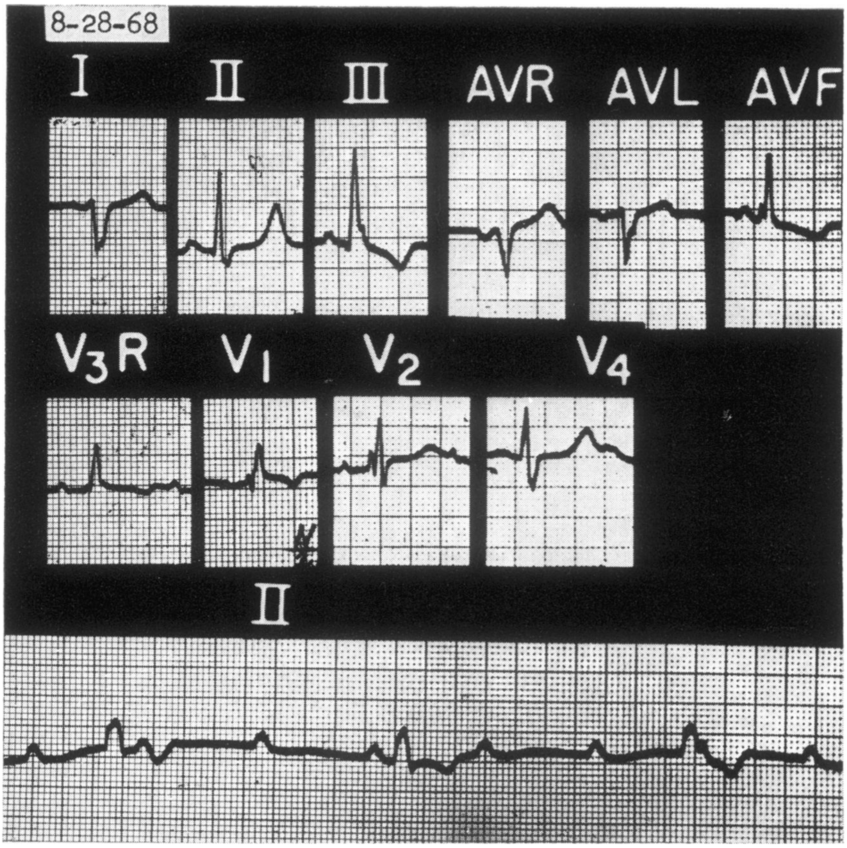

Fig. 7a. First of a series of five electrocardiograms taken on a 42-year-old male with myocarditis and the BBBB syndrome—this ECG shows RBBB, IIVB, and CHB with "LBBB" pattern while lead II was being recorded.

sionally follows operations for ventricular septal defect or Fallot's tetralogy. In congenital heart disease, LAD is very commonly present with endocardial cushion-defects (greater than 80%) and tricuspid atresia but may be seen with ventricular septal defects, corrected transposition, single ventricle, and the preexcitation syndrome. Pulmonary emphysema may cause pseudo-LAD.[3] Chagas' disease may cause SIVB or LIVB.[2]

Since IIVB is a relatively new electrocardiographic entity and is much less frequent than SIVB, less is known about its causes, but we would expect the causes to be similar to those of SIVB, except that IIVB is uncommon after operation and we have not detected it in congenital heart disease.

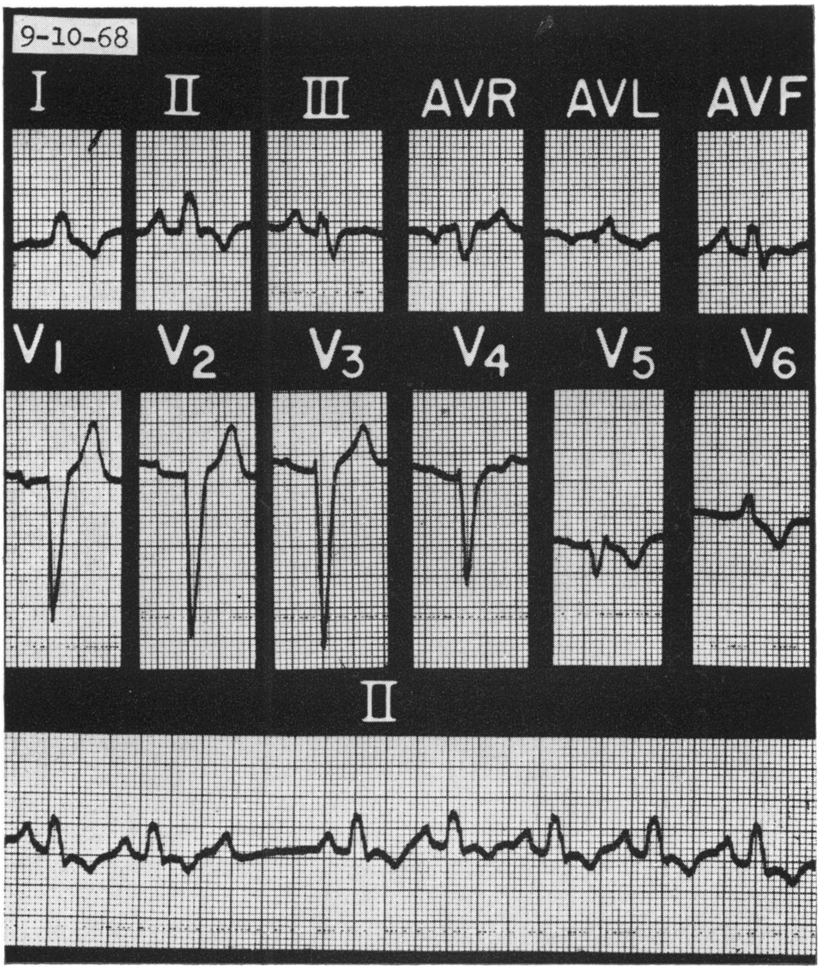

Fig. 7b. First and second degree AV block and "LBBB" pattern.

In some circles it has become fashionable to think of the conduction system of the two ventricles as a trifascicular system (right bundle, left anterior division, and left posterior division); this is not without merit. When RBBB occurs in association with SIVB or IIBV, the patient may be thought of as having PBBBB (bifascicular) block and thus at risk (15% + or −5%)[5] of developing BBBB (trifascicular block) and its consequences, i.e., CHB, syncope, heart failure, and sudden death. With RBBB present in any ECG, the unblocked initial, terminal, and mean QRS vectors and rotation of the unblocked loop (CW or CCW) in the

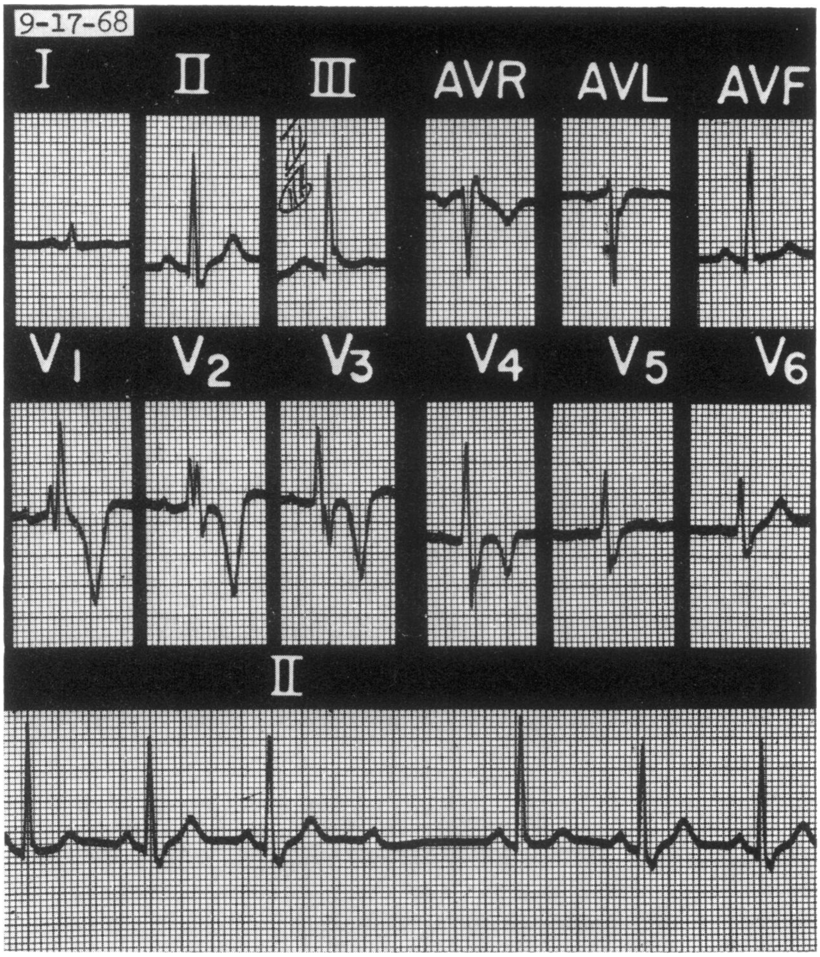

Fig. 7c. ECG illustrates a dropped beat in the rhythm strip, RBBB, and IIVB.

frontal plane may still be analyzed. Thus the combination of RBBB and SIVB or IIVB can be read and the ECG diagnosis of PBBBB is usually possible. Analysis of the ECG illustrated in Figure 5 reveals RBBB, an inferior unblocked initial vector, a leftward superior unblocked terminal vector, and LAD of unblocked mean QRS forces with a CCW loop in the frontal plane; thus RBBB with SIVB = PBBBB. Since the lead II rhythm strip shows CHB with the second beat captured, BBBB has already occurred. A permanent transvenous cardiac pacemaker was used with success in this 62-year-old female who had had one previous syncopal episode.

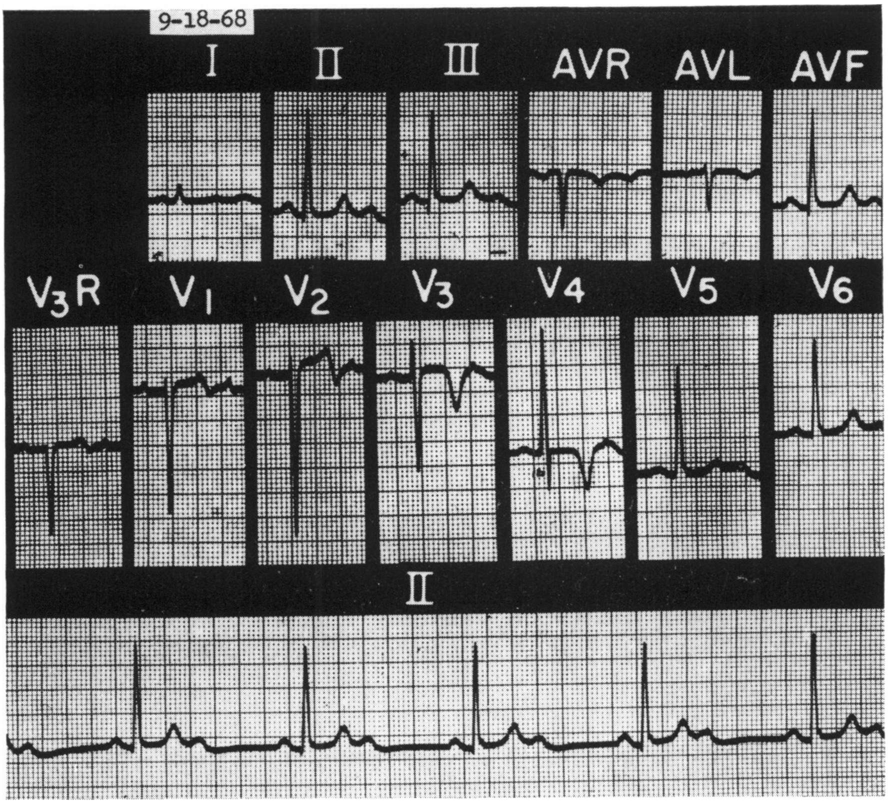

Fig. 8a. ECG shows second degree ("Mobitz II") AV block and IIVB.

Analysis of the ECG shown in Figure 6 reveals RBBB, a leftward horizontal unblocked initial vector, an inferior unblocked terminal QRS vector with a CW loop in the frontal plane; thus RBBB with IIVB = PBBB. Since the rhythm strip in V2 shows CHB with the fourth beat captured, BBBB is already present. This 74-year-old male had had one syncopal episode and was treated successfully with a permanent transvenous cardiac pacemaker.

The electrocardiograms illustrated in Figures 7a, b, c, and Figures 8a and b certainly represent the BBBB syndrome, fully developed; they were all taken on a 42-year-old male who had myocarditis. The ECG in Figure 7a shows RBBB and IIVB but CHB with a "LBBB" pattern occurred while lead II was being recorded. On August 29, 1968, the ECG (not shown) revealed 3:1 AV block and a "LBBB" pattern. In

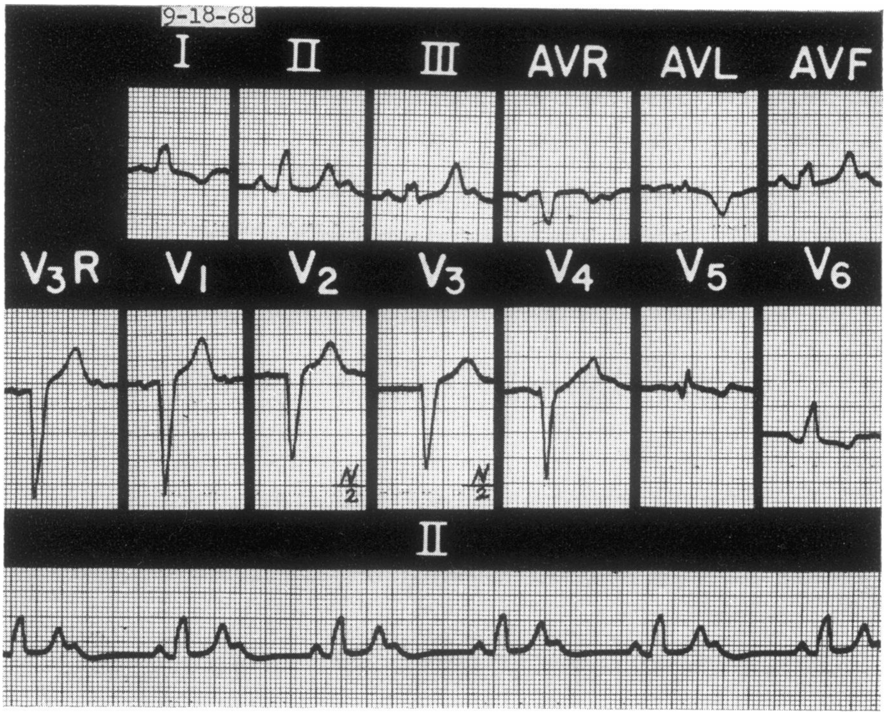

Fig. 8*b*. Second-degree AV block with "LBBB" pattern.

Figure 7b, first and second degree ("Mobitz II") and "LBBB" pattern are noted. The ECG in Figure 7c again shows RBBB and IIVB. In the lead II rhythm strip the fourth sinus beat is dropped and the first and fourth QRS complexes are IIVB without RBBB. The ECG in Figure 3 was taken on this patient on September 16, 1968, and reveals a top normal PR interval and IIBV, but two days later the ECG in Figure 8a showed second degree AV block and IIVB. Another ECG taken later the same day, Figure 8b, revealed second degree AV block and a "LBBB" pattern. This patient was managed successfully with a permanent transvenous cardiac pacemaker. Depending on the symptoms and findings and the clinician's viewpoint, patients with PBBBB may be followed closely, but if first degree block also occurs, some patients may be selected for long-term monitoring or pacing. If syncope, second degree AV block or BBBB develop, pacing is indicated.

Important earlier references are included in our previous communication.[3] A complete bibliography on the entire subject will be found in the excellent book, *The Hemiblocks*, by Rosenbaum, Elizari, and Lazzari,[2] and recent publications[6-26] are listed.

Summary

Left intraventricular blocks and their clinical significance have been described. The association of RBBB with left intraventricular blocks are forms of partial bilateral bundle block and thus potential precursors of bilateral bundle-branch block.

Abbreviations

RBBB	– right bundle-branch block
PBBBB	– "partial" bilateral bundle-branch block
BBBB	– bilateral bundle-branch block
CHB	– complete heart block
LAD	– left axis deviation
SIVB	– superior intraventricular block
IIVB	– inferior intraventricular block
CW	– clockwise
CCW	– counterclockwise
LBBB	– left bundle-branch block
ECG	– electrocardiogram
SPIB	– superior peri-infarction block
IPIB	– inferior peri-infarction block

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